

DIRECT TELEVISION RECEPTION VIA SATELLITES

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ABSTRACT. This paper considers the technical and economic factors involved in satellite television reception. One such satellite could provide nearly 100% coverage of the German Federal Republic. Conditions for development of such a satellite in the Federal Republic are good. Because of the complexity and cost of such a project, the extent to which it can be carried out is unknown. Such satellites are gaining in importance for the developing nations, and previous work has provided a good starting point for international cooperation.

Outline:

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1. Introduction
2. System considerations
3. Television transmitting satellite for the Federal Republic
4. International interest in direct television reception
5. Summary and outlook.

1. Introduction

In recent years television has gained extraordinary importance as an effective mass medium for rapid and comprehensive information about current events, for education and entertainment, and as a forum for independent expression of opinions and for development of political opinion. At present there are some 16 million television viewers in the German Federal Republic. By 1975 an increase to

*Numbers in the margin indicate pagination in the original foreign text.

20 million is expected.

Television programs are transmitted predominantly by terrestrial transmitter networks. The frequencies used are in the VHF (Very High Frequency) range at 41-47 MHz and in the UHF (Ultra High Frequency) range between 580 and 790 MHz. The signals are received with home antennas, and recently often with community antennas which supply a large number of viewers. The signals are received with varying quality, depending on the position of the receiving station in relation to the nearest transmitter. In the Federal Republic, three transmission networks (for the First, Second, and Third programs)) have been built up since the 1950's, with about 180 transmitting stations each. This supplies some 80% of the population. Operation and maintenance of these networks requires some 200 million DM (Marks) per year. Figure 1 shows the transmission network for the Second Program (ZDF).

In the USA and recently also in some European countries, part of the population, especially in the regions of dense population, are supplied by cable television networks. Such networks are limited in extent because the quality of the picture is damaged with increasing cable length. Its particular advantage is that a larger number of programs (10 - 20) can be carried.

The transmitting centers (studios) of the countries are connected to each other by radio links or by special lines, so that programs can be exchanged within large regions (Eurovision, Intervision). Intercontinental exchange of programs, by means of which several hundred million people around the world can simultaneously participate in spectacular events (e. g., lunar landings, Olympic games) has become possible only in the last few years by means of satellites. In contrast to sea cables, satellites provide transmission of wide-band television signals. It is characteristic of these satellites, which were developed for distribution of television transmission, but primarily for international telephone traffic, that they have only a low transmitting power. Therefore, antennas of 20 - 30 m diameter and expensive amplifier installations are required for reception of the signals on the ground.

In view of the rapidly advancing development of communications satellite technology, the question arises, whether programs transmitted from satellites might not be receivable directly by the television viewers. A "Feasibility study for a television transmission satellite for direct transmission of programs to home antennas" performed by Siemens AG under contract to the BMBW in 1969 showed that direct reception is possible, given certain prerequisites.

At the end of 1970 these considerations received a decided impetus from the BMP when it approached the BMBW, which is responsible for space research, with the wish to study the extent to which it would in the future be possible to provide the Federal Republic with three to five more programs by means of television satellites. After seeking other technical possibilities for transmitting more programs, it had become necessary, because the VHF and UHF frequency bands used for terrestrial transmission networks will soon be fully occupied.

In the following, we shall take up consideration of a system for television direct reception based on previous studies, and then report on the interest in direct television reception in other countries and the work going on there.

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2. System Considerations

Figure 2 shows the principle of direct television reception: From a transmitting station on the Earth, the television signal from a studio is sent to a satellite in synchronous orbit (36,000 km). There it is received, converted to another frequency band, amplified, and transmitted over a directional antenna to the region to be supplied. On the ground, an antenna directed toward the satellite receives the signal and carries it to the television set.

Earlier discussions on direct television reception began from the point that the VHF and UHF frequencies used in terrestrial transmission networks would be retained, so that reception on the ground could take place with the previous antennas and television sets. But such a solution requires a direct current power of 15 - 50 kW and a parabolic antenna of some 6 - 20 meters diameter, depending

on the quality of the video signal desired and the quality of the home receiver, to provide a region of the size of the Federal Republic with only one program. For transmission of 3 - 5 programs, then, powers of 50 - 200 kW would be needed. This is outside the range of present technological capabilities.

But with the increasing occupation of the VHF and UHF frequencies and the range up to 10 GHz by fixed and mobile radio services, it became necessary to open up higher frequency regions, particularly the 12 - 14 GHz region. This simultaneously opened up new possibilities for direct reception.

With higher frequencies, more power is required, of course, for transmission of signals from the satellite to the ground, but wider frequency bands are available, so that power-saving frequency modulation can be used to transmit the signals instead of the current amplitude modulation. It is also important that at higher frequencies antennas of smaller diameter are sufficient. To be sure, for the ground receivers a conversion to the 12 GHz frequency range means that a parabolic antenna becomes necessary, as well as front-end devices (frequency and modulation converters) because the usual commercial television sets are equipped to receive amplitude-modulated signals in the VHF and UHF bands. /4

In this way direct television reception becomes technically possible, with thanks due also to advances which have been made in satellite technology. But its introduction presumes that the television viewer is willing to bear the cost of the special antenna and the converters. He will be more willing if he can be offered several programs of good quality.

A brief poll has shown that 18% of the television viewers, or about 3 million, are interested in additional programs and are also ready to make the investment. Interest in current information and entertainment may well be in the foreground, along with the possibilities for vocational advancement through training programs.

3. Television transmitting satellite for the Federal Republic

3.1 Results of the first studies

In the Fall of 1971 the Society for Space Travel Research, Inc., granted contracts to two German industrial groups (AEG-Telefunken, Dornier-System, Erno-Raumfahrttechnik GmbH, Siemens AG, Messerschmitt-Bölkow-Blohm GmbH, Standard Elektrik Lorenz) to perform systems studies on the possibilities of direct television reception in the Federal Republic. The studies were to provide concepts for a television transmitting satellite and to estimate the technological, time, and financial cost for the possible realization of such a project.

These studies were concluded recently. A description and discussion of the various suggestions will follow in the next lecture by Dipl.-Ing. Billig, GfW. Here only the major results will be mentioned:

- 800-1000 kg mass for 3-5 TV programs
- solar cell generator for power output of 4-6 kW; 1.2 kW/channel
- transmitting antenna with 1° angular aperture
- 3-axis attitude stabilization with 0.1° accuracy
- transmitting power (traveling wave tube) of 500-800 W per television channel
- development costs: 600-800 million DM
- cost of an operational satellite including launch:
100-130 million DM

Ground receiving equipment

- for individual reception:
 - parabolic antenna 0.8 m in diameter
 - converter (frequency and modulation converters)
 - Cost about 1,500 DM.
- for community reception:
 - parabolic antenna with 2 - 3 m diameter, supplementary equipment, more expensive, but less critical as it is carried by a larger number of television viewers.

3.2 Comparison with alternative solutions

Of course, the results of these studies can only be considered preliminary. But they provide a first evaluation of direct television reception in comparison to conceivable alternatives for the future provision of television to the Federal Republic, namely by

- terrestrial transmission networks in the 12 GHz frequency range
- cable television networks.

3.2.1 Terrestrial 12 GHz transmission networks

Because line-of-sight links are necessary at these frequencies, and the transmitting range is only some 15 - 20 km, about ten times as many transmission stations would be required to build up such a network for the Federal region, compared to the VHF and UHF networks. According to estimates by the Federal Post Office, about 1,300 transmitters would be needed for coverage of the Federal Republic (86% coverage). The annual operating costs (personnel, maintenance, depreciation, etc.) would be about 700 million DM. Construction of such a network would presumably require around 20 years, as for the transmission network of the First Program. Initial costs would be 6.5 million DM.

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3.2.2 Cable television network

Supply of the Federal Republic with a cable television network would, according to estimates by the Federal Post Office, lead to capital costs on the order of 40 - 60 thousand million DM. If one considers that the development of the German telephone network to its present subscriber density of 16% took about 25 years, then the installation of a television cable, which is far more complex technically, will require a similar time.

In comparison to the alternative solutions mentioned, the Federal Post Office has calculated a capital cost of 900 - 1,200 million DM and annual operating costs of 100 - 130 million DM for supplying the Federal Republic with a television transmitting satellite having an operating life of 10 years. It was assumed that

with a reliability of 0.9 and 0.75 for the satellite and booster rocket, respectively, some 7 - 8 satellites would be required to maintain operation for ten years, and that each launch (satellite and booster rocket) would cost 100 - 130 million DM. A comprehensive economic study would, of course, also have to include the cost which would be required on the private side for antennas and supplementary equipment. But it can already be seen that a television satellite promises faster and more economical supply of the Federal Republic with additional programs than do the terrestrial alternatives.

The optimal solution was considered to be the design of the satellite for the following reception possibilities:

- individual reception, primarily in regions of low population density
- community antennas for housing blocks and small towns
- more expensive receiving stations to feed the programs into
 - cable television networks for small cities or city areas
 - 12 GHz transmitters for rebroadcast in special geographic areas (such as mountain valleys).

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In this way the Federal Republic could be supplied almost completely with more programs at an earlier time.

4. International interest in direct television reception

4.1 European region

It can be seen from Figure 4 that the principal European language areas are of approximately the same extent. That is, a satellite developed for the Federal Republic, with an antenna having an angular aperture of 1.4° , for instance, would also be suitable for covering the English or French language regions.

Studies carried out in France refer to a television transmission satellite with a weight of 500 kg, and to the design of a transponder and the suitability of traveling wave tubes and klystrons as transmitter tubes.

Studies are under way in England on the technical aspects and the economy of direct television reception. As preparation for the possible development of a television transmitting satellite, a geostationary technological satellite (GTS) is planned. It is intended to serve, among other things, for direct reception experiments in the 12 GHz region. Other studies are following, such as on how to manufacture the parabolic antennas required for individual reception and the converters on a large scale at the most favorable price.

In Belgium and Holland it appears that they plan to extend further the already partially existing cable television network. There could be interest in Switzerland and Austria in perhaps using the transmissions broadcast by a German television satellite to supplement their own television program.

In the last year, brisk activity has come out of the ESRO. In particular, it has had the technical and economic aspects for individual and community reception investigated. Also, so-called adaptation studies have been granted to the three European company consortiums, COSMOS, MESH, and STAR. It was the goal of these studies to test how the concepts suggested by the consortiums could be modified to make direct television reception possible. Further studies deal with critical system parameters, subsystems, and components of such satellites.

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4.2 Extra-European region

Transmission of television signals directly to the viewers (village groups) will be realized for the first time with the ATS-F (Applications Technology Satellite) (see Figure 5) which is now undergoing development by NASA. Its launch is planned for 1973. The satellite is equipped with a 9 m transmitting antenna. Reception on the ground is done with an antenna of 3 m diameter.

With the ATS-F, training programs are to be carried out first in some Rocky Mountain states from a synchronous position at 100° W. After about 1974 the satellite will be placed at a position 35° East. Then, under the terms of an agreement concluded between the USA and India it will broadcast to 5,000 Indian communities for the period of one year. The goals of this pilot project, called SITE (Satellite Instructional Television Experiment) are, in particular, improvement of agricultural work methods, provision of health techniques, family planning, and teacher training. Receiving antennas, power supply systems, and the television sets are being produced in India. Development of their own satellite (INSAT = Indian National Satellite) is planned for continuation of the SITE program.

A Communications Technology Satellite (CTS) is being developed by Canada in cooperation with the NASA. With a traveling wave tube having a transmitting power of 200 W it should make possible direct reception with 2.5 m antennas. Solar cell panels which can be unfolded and automatically oriented toward the sun are being used for power supply in the satellite (some 1.2 kW).

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Aside from direct television reception, a series of other experiments are to be performed (see Figure 6), including telephone traffic with portable antennas of 1.2 m diameter, to investigate the possibilities offered for unlocking the giant areas in northern Canada with high-power satellites.

The United Nations place great importance on direct television reception for access to developing countries. The related cultural, economic, legal and political questions are being treated in the UN working group for direct television.

The UNESCO (United Nations Educational, Scientific and Cultural Organization), with financial support from the UNDP (United Nations Development Program) is carrying out extensive studies in South America (Andes countries, Brazil) in order to investigate the potential applications of satellites for educational, cultural, and economic purposes. Such project studies are also being introduced in other developing countries.

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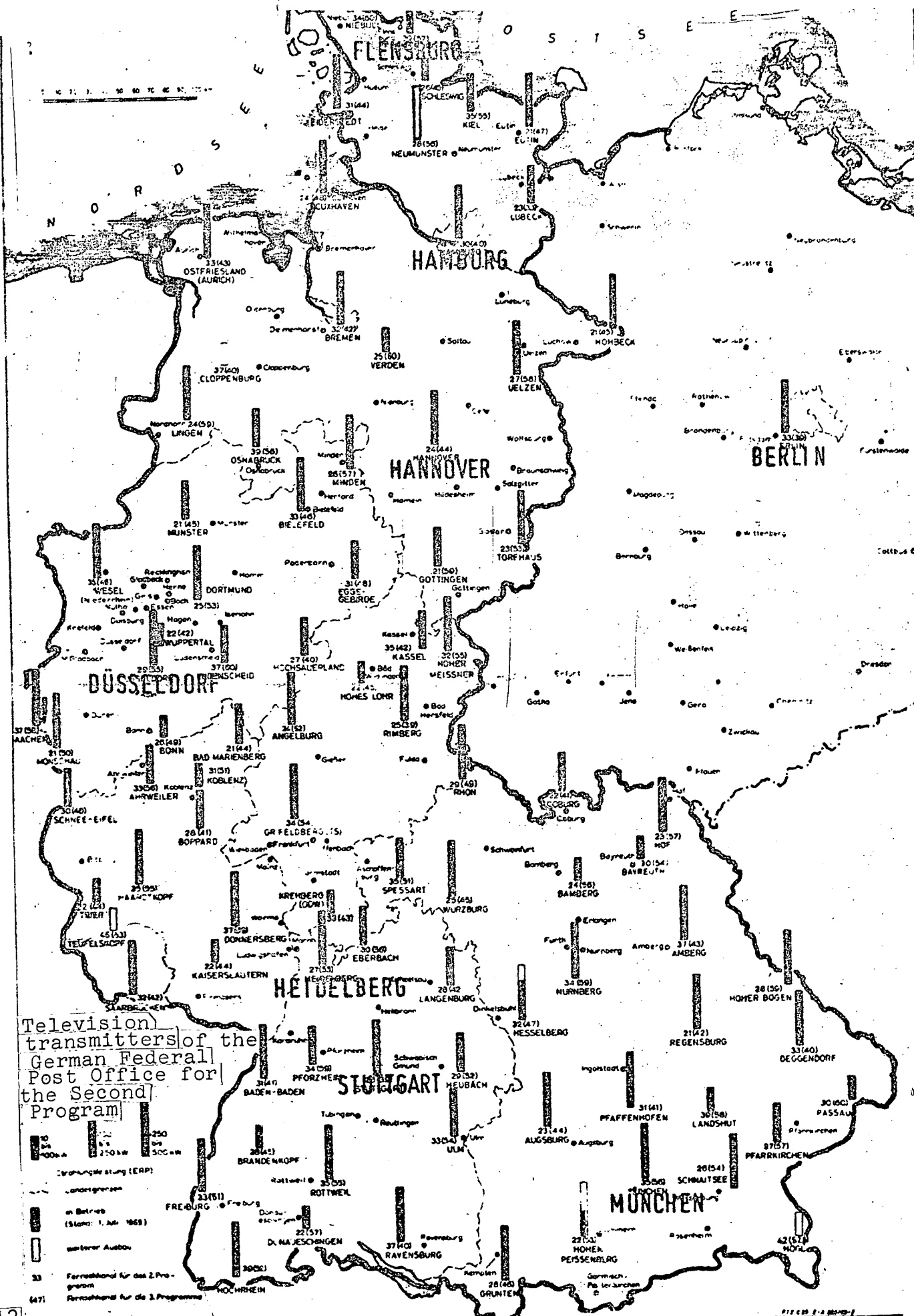


Figure 1. Special network for the Second German Television (ZDF)

Schematic representation
of the transmission link

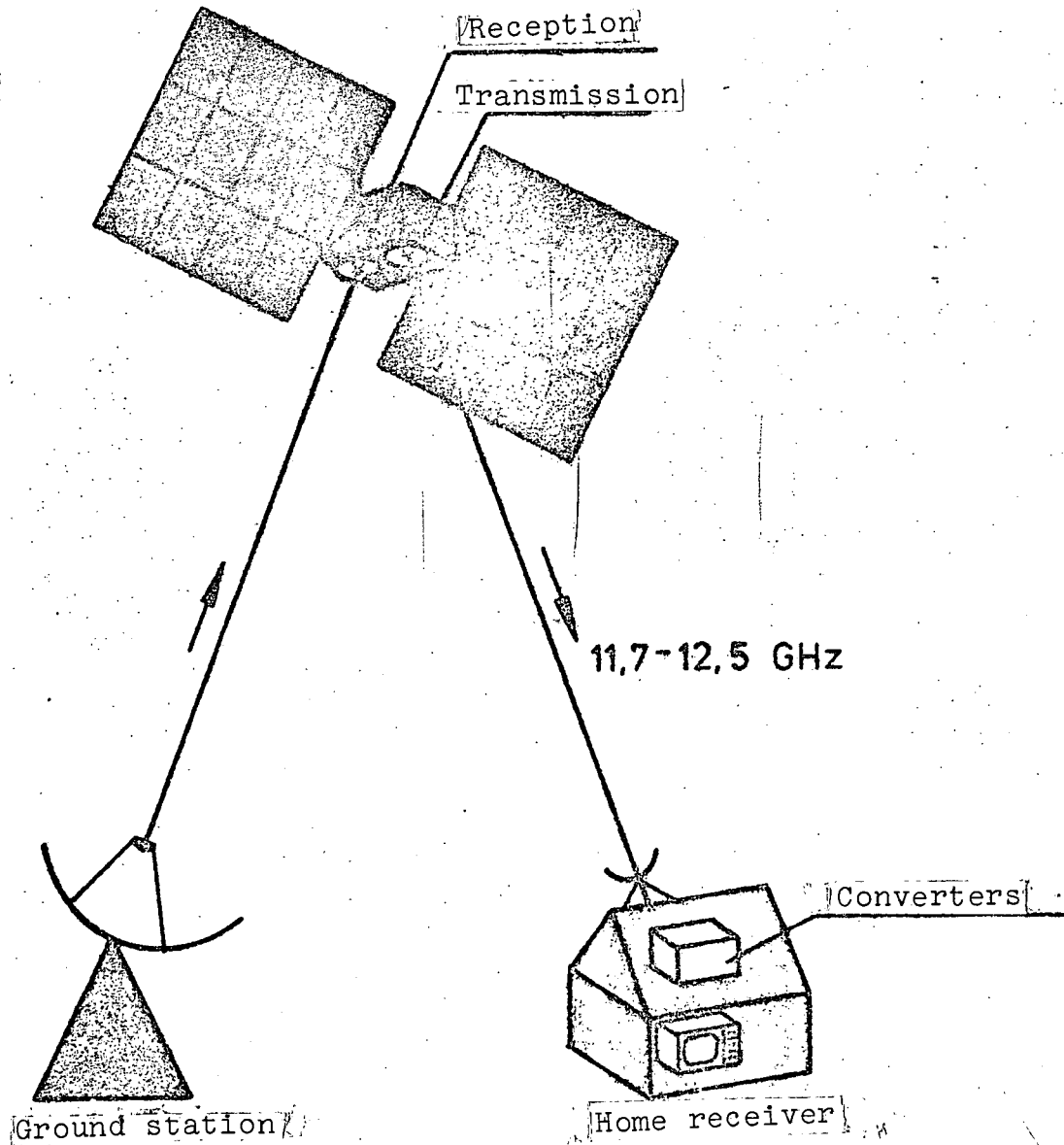


Figure 2. Principle of direct television reception

*Translator's note: Figure 3 not attached.



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Figure 4. Coverage of European language regions by means of television transmission satellites

*Translator's note: Figure 5 not attached.

CTS PROJECT

Experimental Communications Network

Figure 6. Potential applications for the Canadian Test Satellite (CTS).

